(12) UK Patent Application (19) GB (11) 2 238 349 (13) A

(43) Date of A publication 29.05.1991

(21) Application No 8926705.8

(22) Date of filing 25.11.1989

(71) Applicant
T & N Technology Limited

(Incorporated in the United Kingdom)

Cawston House, Cawston, Rugby, Warwickshire, CV22 7SA, United Kingdom

(72) Inventor
Duncan Robert Bury

(74) Agent and/or Address for Service
D J Goddard et al
T & N Plc, Bowdon House, Ashburton Road West, Trafford Park, Manchester, M17 1RA, United Kingdom

(51) INT CL[5]
F01L 3/02, C23C 4/10

(52) UK CL (Edition K)
F1B B2Q3C
C7F FGA FPCX FP810 FQ841 FQ853 FQ862 FQ887 FQ914 FR820 FR841 FR852 FR853 FR862 FR887 F1021
U1S S1901

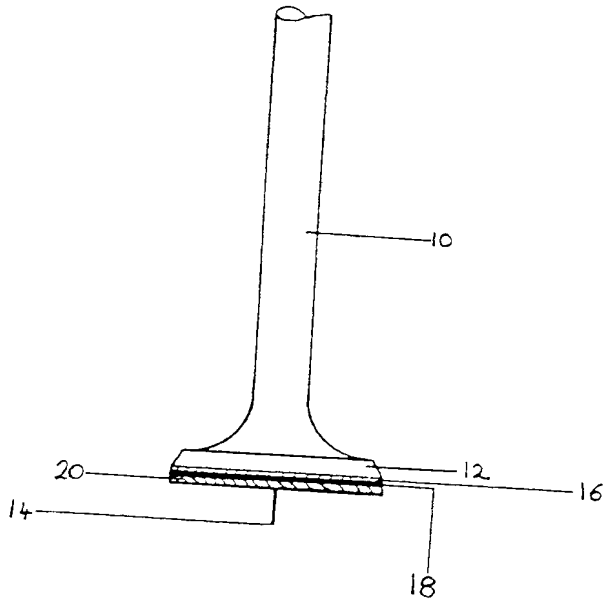
(56) Documents cited
EP 0217991 A1 EP 0194701 A1 EP 0051300 A1
EP 0049396 A1

(58) Field of search
UK CL (Edition J) C7F, F1B
INT CL[4] C23C, F01L

(54) **Ceramic faced i.c. engine valves**

(57) The valve face 14 is coated with a layer 18 of a ceramic material with an overlying layer 20 of a metallic material, the ceramic material serving as an insulation medium and the metallic material serving to protect the ceramic layer from the ingression of waste products from the combustion mixture which reduce the insulation properties of the ceramic. The layers may be plasma sprayed with the ceramic being 8% yttria-stabilized zirconia and the metallic material Ni, NiCrAlY, CoCrAlY or FeCrAlY. The face coating may be graded from 100% metallic to 100% ceramic to 100% metallic outermost. The layers may be located within a recess (22, Figs. 3 and 4) in the valve head and the outermost metallic layer may extend over the recess rim.

Fig. 1



GB 2 238 349 A

Fig. 1

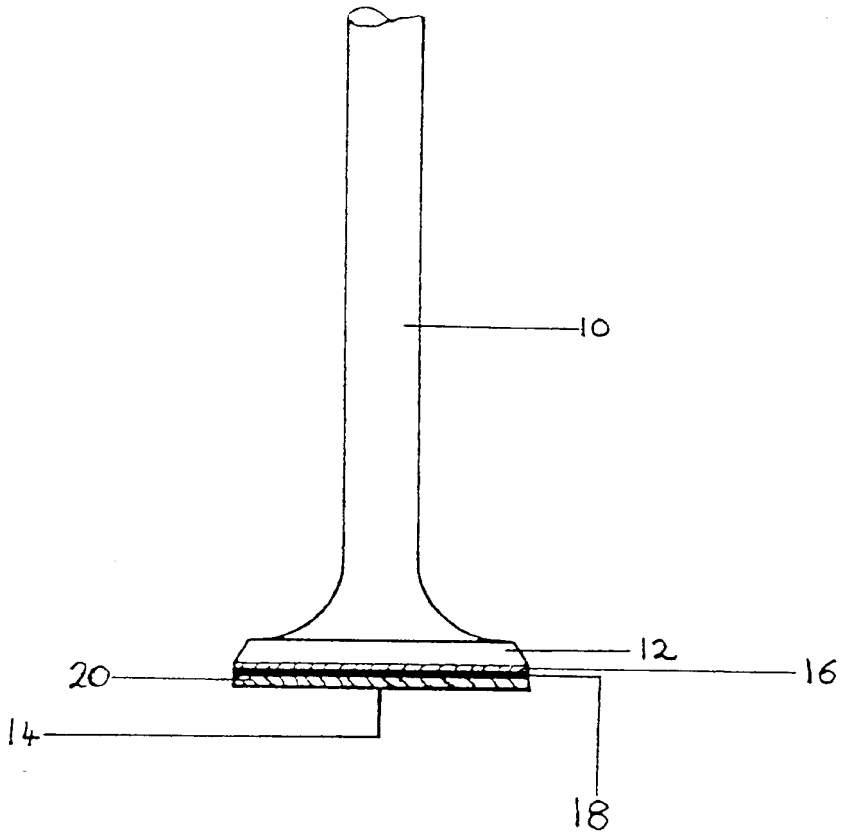


Fig. 2

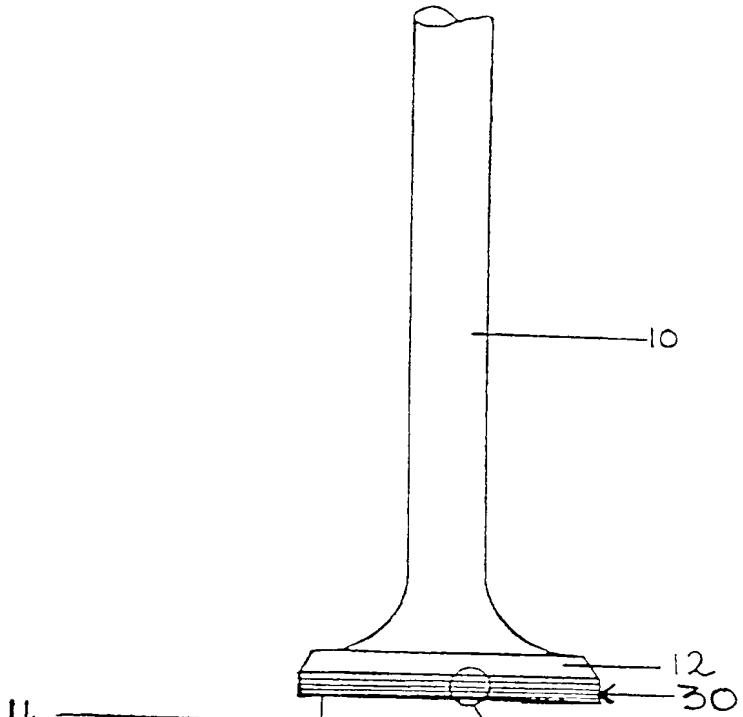


Fig. 2a

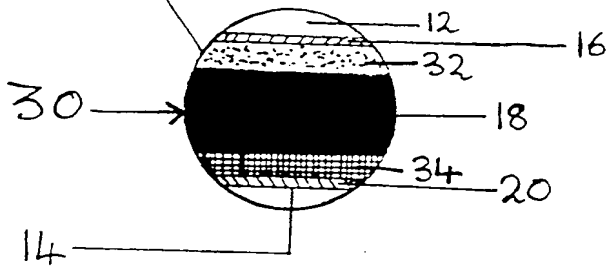


Fig. 3

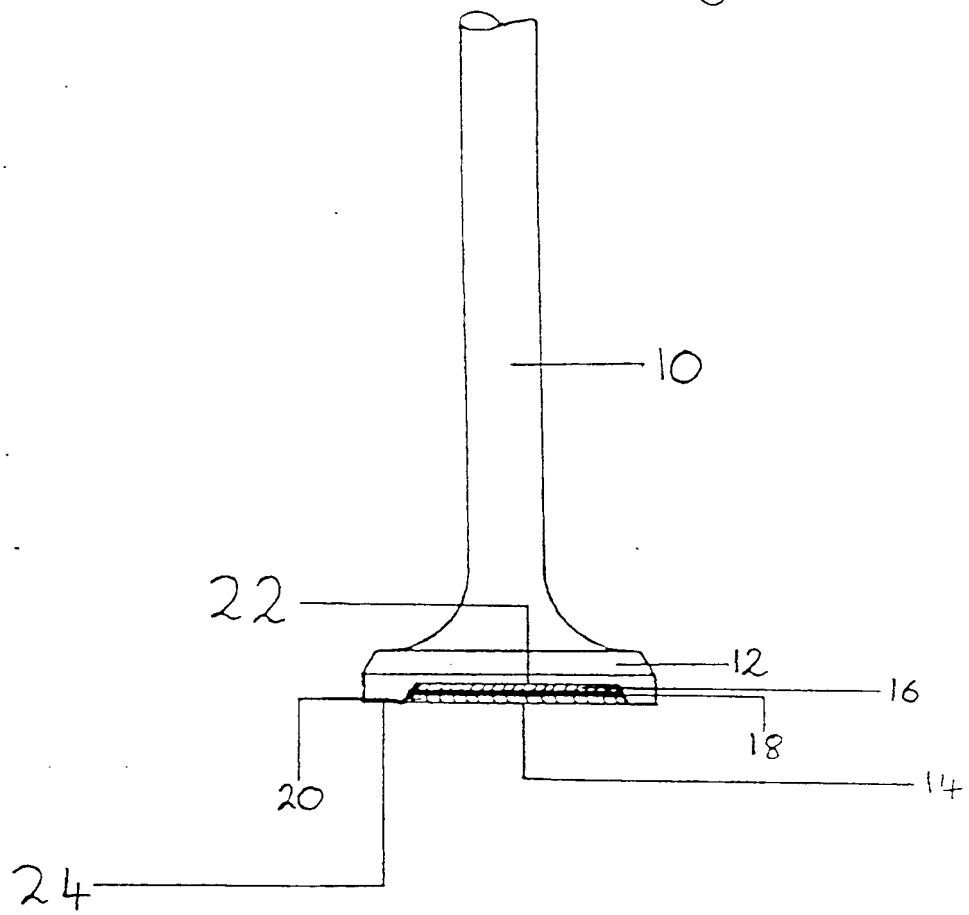
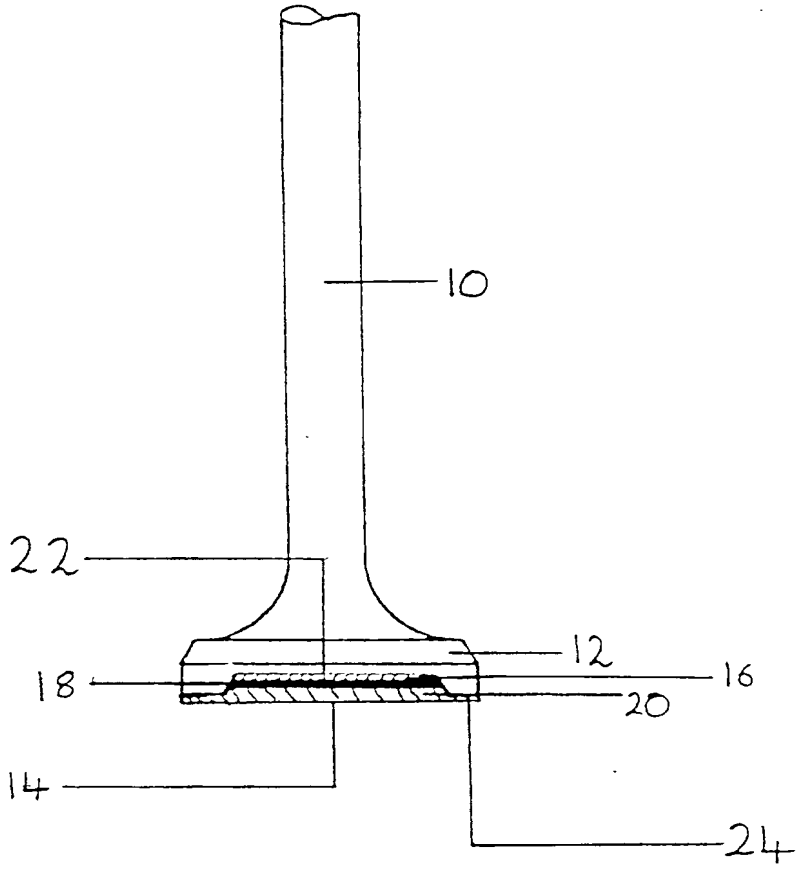


Fig. 4



Ceramic coated engine valves

This invention relates to valves for use in internal combustion engines and particularly to poppet valves having a thermal insulation coating on the face within the combustion chamber.

A problem associated with internal combustion engines and especially with diesel engines is loss of heat from the combustion chamber through the valves which in turn become too hot. It is desirable to lower the operating temperature of the valve; this is best achieved by insulating the valve to prevent it from absorbing as much heat from the combustion chamber.This also reduces heat loss from the combustion chamber thereby leading to an increase in thermodynamic temperature of the combustion

chamber which may reduce the levels of undesirable emissions from the engine, whilst leading to smaller cooling systems and hence more efficient engines.

One method of insulating the poppet valves is to coat the face of the valve which is within the combustion chamber with a layer of a ceramic material. The use of ceramic coatings to insulate engine components in this way is well known.

A problem which arises when coating the valve face in this manner is the ingression of combustion products into the porosity of the sprayed ceramic material. Such combustion products may chemically attack the valve and/or ceramic layer and may reduce the insulation and thermal shock resistance properties of the ceramic layer by filling the porosity of the ceramic material. Also, secondary explosions ("knocking") may occur owing to wet fuel entering the pores of the hot ceramic material.

It is known to treat ceramic-coated engine components such as cylinder liners, etc, with porosity fillers in order to prevent the ingression of undesirable materials into the porosity of the ceramic layer. The "MONITOX" (trade mark) treatment of Monitor Coatings Limited uses chromium-based materials as a porosity filler; however, this treatment reduces the insulation and thermal shock resistance

properties of the ceramic layer by filling the porosity through the sprayed layer.

It is an object of the present invention to produce an insulated valve for use in an internal combustion engine which does not suffer from the problems caused by the ingression of combustion products or from a reduction in the porosity level of the ceramic material.

According to the present invention there is provided a valve for use in an internal combustion engine characterised in that the valve face has a coating of a layer of a ceramic material on top of which is a coating of a layer of a metallic material.

The ceramic material used is preferably zirconia-based and is more preferably partially stabilised zirconia.

The material used for the metallic coating must exhibit resistance to high temperature degradation in a corrosive environment and desirably, should also have a low heat capacity and high thermal conductivity. The material used should also form a good bond with the ceramic material and/or the valve face material.

Suitable materials for the purpose of this invention include NiCrAlY, CoCrAlY, FeCrAlY or Ni.

The use of such metallic materials to cover the ceramic layer serves to prevent the ingression of combustion products into the pores of the ceramic material without materially affecting the insulating properties of said ceramic material.

In a first preferred embodiment of the invention the valve face is coated with firstly a suitable bond coat on top of which is a graded layer comprising a metallic material and a ceramic material the proportions of which alter inversely such that immediately adjacent to the bond coat the graded layer contains 100% metallic material and 0% ceramic material whilst at the top of the graded layer, furthest away from the bond coat, the graded layer contains 0% metallic material and 100% ceramic material; on top of the graded layer is a further layer comprising 100% ceramic material which in turn is coated with a second graded layer comprising metallic material and ceramic material in inversely altering proportions such that immediately adjacent to the ceramic layer the graded layer comprises 0% metallic material and 100% ceramic material whilst at the top of the second graded layer, furthest away from the ceramic layer, the graded layer comprises 100% metallic material and 0% ceramic material; on top of the second graded layer is a final layer comprising 100% metallic material.

The graded layers are applied to a thickness in the range 0.05mm to 0.25mm and more preferably in the range 0.1mm to 0.2mm.

In a second embodiment of the invention the valve face has a recess which contains the ceramic material and where the overlying metallic layer is flush with the annular rim formed on the valve face.

An advantage to be gained from this embodiment is that the edges of the ceramic layer are especially prone to attack. By confining the ceramic layer within the recess in this manner the edges of the layer are less vulnerable to attack .

In a third embodiment of the invention the valve face has a recess which contains the layer of ceramic material and where the overlying metallic material extends out of the recess to cover the annular rim formed on the valve face.

In a fourth embodiment of the present invention the valve face has a recess which is filled with an insulating and protective layer as described in the first preferred embodiment of the invention.

A valve may comprise more than one of the preferred features described above.

The edge of the recess may be chamfered with an angle in the range of 25 degrees to 75 degrees and preferably in the range of 30 degrees to 60 degrees.

In all embodiments of the invention, the ceramic material is applied to a thickness in the range 0.5mm to 2.0mm and more preferably in the range 1.0mm to 1.5mm.

The overlying metallic material may be applied to a maximum thickness at any point on the valve face, of up to 1.0mm.

The invention will now be more fully described by way of illustration only with reference to the following Examples and accompanying drawings of which:-

Figure 1 shows a section through a valve according to the present invention;

Figures 2 and 2a show a section through a first alternative embodiment and the fine detail thereof respectively, of a valve according to the present invention;

Figure 3 shows a section through a second alternative embodiment of a valve according to the present invention.

Figure 4 shows a section through a third alternative embodiment of a valve according to the present invention.

Referring now to the drawings and where the same features are denoted by common reference numbers:-

Figure 1 shows a poppet valve indicated generally at 10 having a head 12 with a face 14 lying within a combustion chamber (not shown).The face 14 has a coating of a layer 16 of a suitable metallic bond coat which in turn has a coating of a layer 18 of a ceramic material. On top of the ceramic layer lies a layer 20 of a metallic material.

Figures 2 and 2a show a poppet valve, substantially as shown in Figure 1, and the fine detail of the face 14 of the valve respectively. The face 14 has a multi-layer coating 30 comprising a layer 16 of a suitable metallic bond coat on top of which is a graded layer 32 containing codeposited metallic and ceramic material, the proportions of which vary inversely such that at the boundary with the bond coat layer the graded layer contains 100% metallic material: 0% ceramic material and at the top of the graded layer the composition is reversed, 0% metallic:100% ceramic. The graded layer is in turn covered with a layer 18 of ceramic material which is itself covered with a further graded layer 34 again containing metallic and ceramic materials in inversely varying proportions such

that at the boundary with the ceramic layer 18 the second graded layer contains 0% metallic:100% ceramic whilst at the top of the graded layer it contains 100% metallic:0% ceramic. The second graded layer is coated with a final layer 20 of a metallic material.

Figure 3 shows a poppet valve, substantially as shown in Figure 1, wherein the face 14 has a recess 22 which contains a layer 16 of a suitable metallic bond coat on top of which is a layer 18 of a ceramic material over which lies a layer 20 of a metallic material which completely fills the recess such that the surface of the metallic layer is flush with the annular rim 24, formed on the valve face.

Figure 4 shows a poppet valve sustantially as shown in Figures 1 & 3, wherein the layer 20 of a metallic material fills the recess 22 and extends out of the recess to cover the annular rim 24 formed on the valve face.

Example 1

A poppet valve for use in an internal combustion engine was selected. The combustion face of the valve was roughened by a process of wet grit blasting to minimise retained grit. The roughened surface was then coated with a layer of AMDRY 995 (trade mark) NiCrAlY bond coat, to a

depth of 0.025mm, by plasma spraying. A layer of ceramic material comprising 8% yttria-stabilised zirconia was then sprayed onto the bond coat layer to a thickness of 1.0mm using a plasma spraying unit. Finally, a layer of a metallic material comprising AMDRY 995 NiCrAlY was plasma sprayed onto the 'as-sprayed' ceramic layer to a thickness of 0.1mm.

Example 2

A poppet valve as used in Example 1 was selected and a recess machined into its combustion face to a depth of 1.125mm and to 1.0mm from the edge of the valve face, the edge of the recess being chamfered to an angle of 45 degrees. The valve face was masked to protect the annular rim so formed and the recess was then roughened by wet grit blasting. The recess was then coated with layers of AMDRY 995 NiCrAlY, 8% yttria-stablisied zirconia and a further layer of AMDRY 995 as in Example 1 such that the recess was completely filled and the final NiCrAlY layer was flush with the annular rim.

Example 3

A poppet valve as used in Example 1 was selected and its combustion face was roughened by wet grit blasting. The roughened surface was then coated with a layer of AMDRY 995 NiCrAlY bond coat to a depth of 0.025mm by plasma spraying. AMDRY 995 NiCrAlY was then codeposited, by plasma spraying, with ceramic material comprising 8% yttria-stabilised zirconia on top of the bond coat to a depth of 0.15mm, the proportions of ceramic material and NiCrAlY altering inversely such that the graded layer produced contained 100% NiCrAlY:0% ceramic immediately adjacent to the bond coat layer and 0% NiCrAlY:100% ceramic at the top of the graded layer, furthest away from the bond coat. A layer of the ceramic material was then applied on top of the graded layer to a depth of 1mm, over which was applied a further codeposited layer, to a depth of 0.15 mm, comprising NiCrAlY and the ceramic material. The proportions of NiCrAlY to ceramic material in this second graded layer again varied, from 0% NiCrAlY:100% ceramic to 100% NiCrAlY:0% ceramic. Finally, a layer of NiCrAlY 0.025mm deep was applied on top of the second graded layer.

CLAIMS

1. A valve for use in an internal combustion engine wherein the valve face has a coating of a layer of a ceramic material on top of which is a coating of a layer of a metallic material.

2. A valve according to claim 1 wherein the ceramic material is zirconia-based.

3. A valve according to claim 2 wherein the ceramic material is partially stabilised zirconia.

4. A valve according to any one of claims 1, 2 or 3 wherein the metallic material is selected from NiCrAlY, CoCrAlY, FeCrAlY or Ni.

5. A valve according to any one preceding claim wherein the valve face is coated with firstly a suitable bond coat on top of which is a graded layer comprising a metallic material and a ceramic material the proportions of which alter inversely such that immediately adjacent to the bond coat the graded layer contains 100% metallic material and 0% ceramic material whilst at the top of the graded layer, furthest away from the bond coat, the graded layer contains 0% metallic material and 100% ceramic

material; on top of the graded layer is a further layer comprising 100% ceramic material which in turn is coated with a second graded layer comprising metallic material and ceramic material in inversely altering proportions such that immediately adjacent to the ceramic layer the graded layer comprises 0% metallic material and 100% ceramic material whilst at the top of the second graded layer, furthest away from the ceramic layer, the graded layer comprises 100% metallic material and 0% ceramic material; on top of the second graded layer is a final layer comprising 100% metallic material.

6. A valve according to claim 5 wherein the graded layers are applied to a thickness in the range 0.05mm to 0.25mm.

7. A valve according to claim 6 wherein the graded layers are applied to a thickness in the range 0.1mm to 0.2mm.

8. A valve according to any one preceding claim wherein the valve face has a recess which contains the ceramic material and where the overlying metallic material is flush with the annular rim of the valve face.

9. A valve according to claim 8 wherein the metallic material extends out of the recess to cover the annular rim of the valve face.

10. A valve according to claims 8 or 9 wherein the edge of the recess is preferably chamfered at an angle in the range of 25 degrees to 75 degrees.

11. A valve according to claim 10 wherein the edge of the recess is preferably chamfered at an angle in the range of 30 degrees to 60 degrees.

12. A valve according to any one preceding claim wherein the ceramic material is applied to a thickness in the range 0.5mm to 2.0mm.

13. A valve according to claim 12 wherein the ceramic material is applied to a thickness in the range 1.0mm to 1.5mm.

14. A valve according to any one preceding claim wherein the metallic material is applied to a maximum thickness of up to 1.0mm.

15. A valve substantially as hereinbefore described with reference to the accompanying specification and to Examples 1, 2 or 3 thereof and to Figures 1, 2, 2a, 3 or 4 of the accompanying drawings.

Published 1991 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from